

[54] **MICRO-TORQUE POTENTIOMETER**
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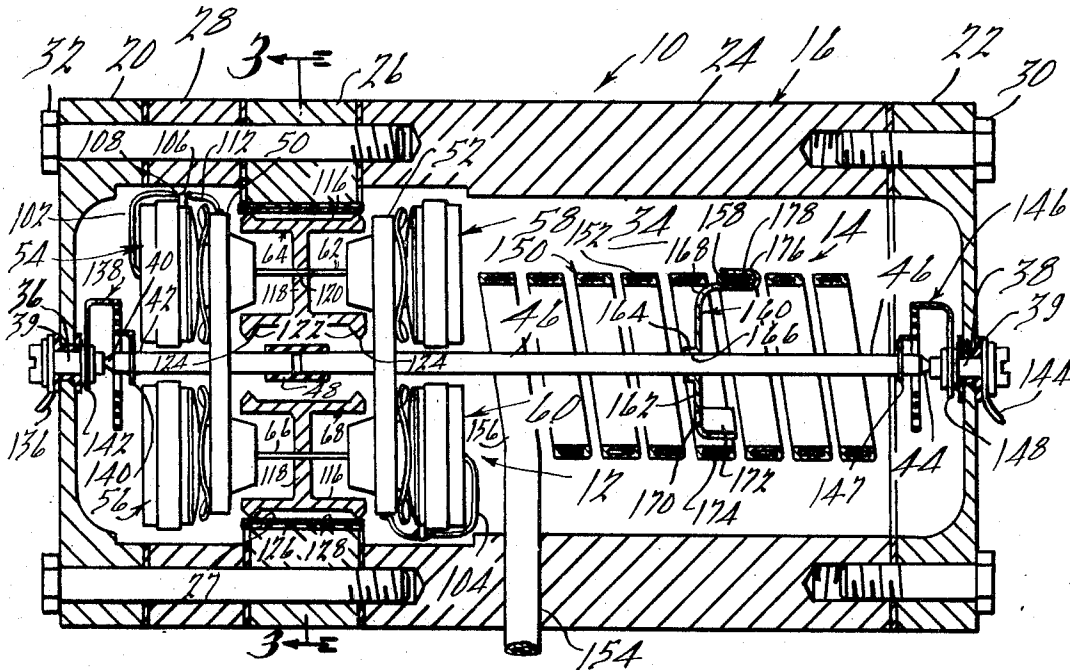
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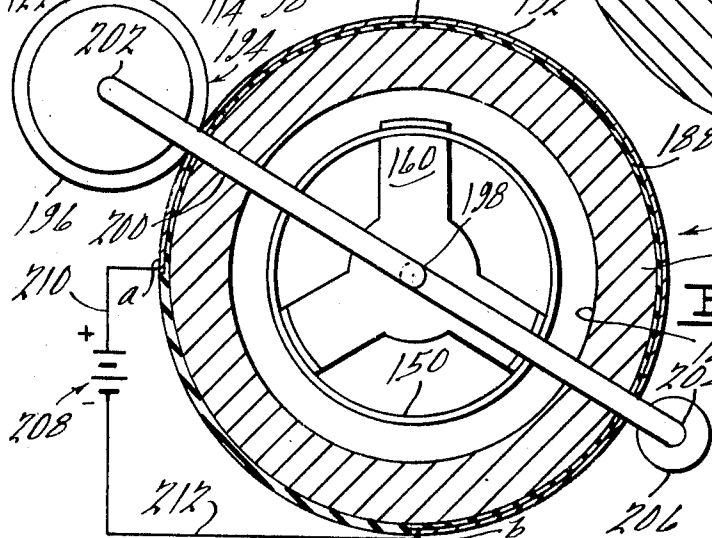
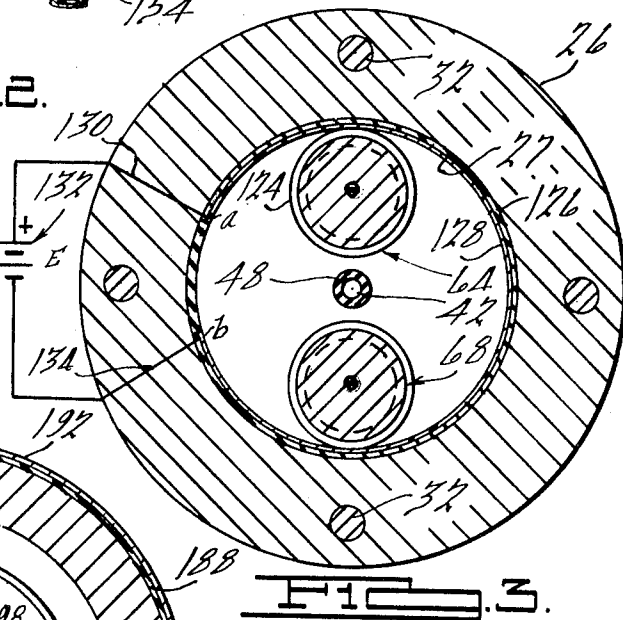
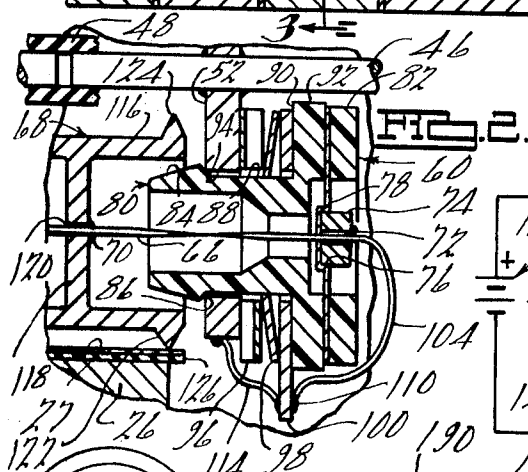
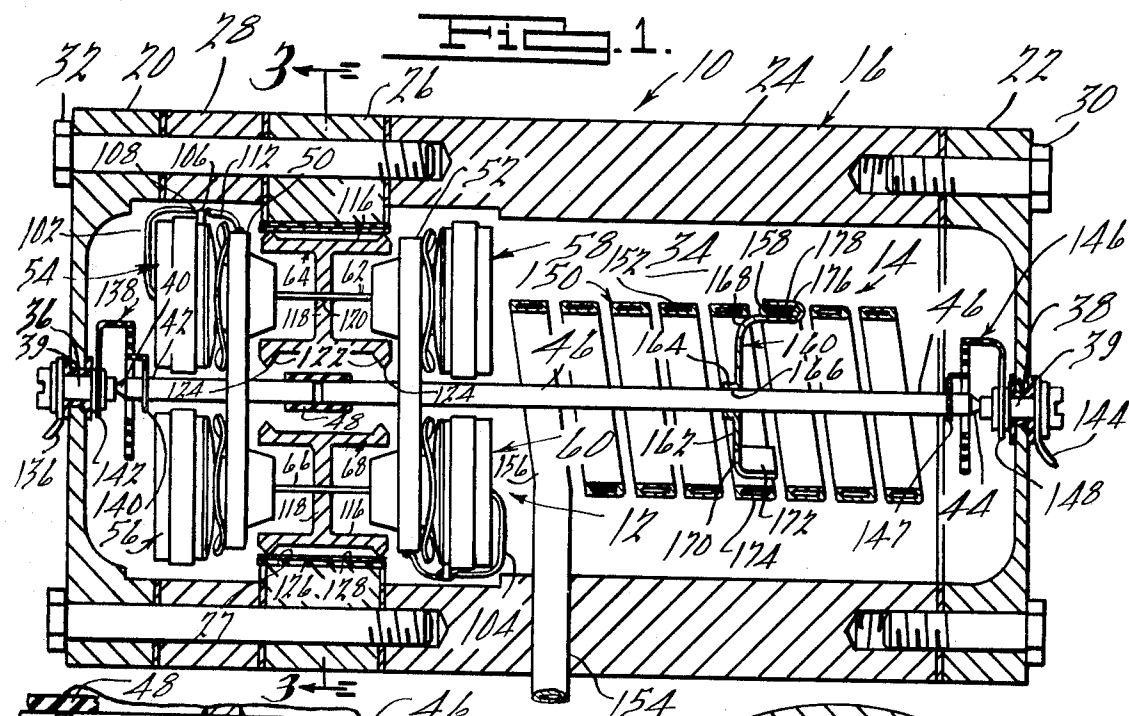
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[57] **ABSTRACT**

A potentiometer requiring extremely low torque input for the operation thereof preferably having a contact roller of magnetic material engaging an elongated resistive element, a taut-band suspension for the contact roller, and a magnet establishing a magnetic field resulting in an engagement force between the contact roller and the resistive element. The potentiometer of this invention is particularly suitable for use as an electrical output for a multi-convolution Bourdon tube.

15 Claims, 4 Drawing Figures





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MICRO-TORQUE POTENTIOMETER

BACKGROUND OF THE INVENTION

1. Field of the Invention

Potentiometers and electrical output devices for Bourdon tubes and the like.

2. Description of the Prior Art

It is known in the art to utilize a rotary potentiometer in combination with a Bourdon tube to provide an output signal which varies in accordance with fluid pressure delivered to the Bourdon tube. The potentiometers of these systems tend to have inherently high friction which detrimentally effects the accuracy, sensitivity and consistency of the readings provided by these devices.

Rotary potentiometers using rollers as contact elements are also known in the art. Although potentiometers of this variety exhibit lower operating friction than the sliding-contact potentiometers, the springs which are used to provide an engagement force between the rollers and the resistive element tend to make these devices particularly sensitive to surface irregularities. Moreover, the contact roller mountings and electrical connections to the rollers used in these devices are a source of considerable friction.

SUMMARY OF THE INVENTION

The present invention provides a novel potentiometer which requires an extremely low torque input for the operation thereof. The potentiometer of this invention is particularly advantageous when used in combination with a Bourdon-type tube pressure transducer such as those used in gas absorption thermometers since it provides a level accuracy, sensitivity, and consistency which is not attained by the prior art Bourdon tube and potentiometer combinations.

More specifically, the potentiometer of this invention uses at least one roller which is constructed of magnetic material in combination with a magnet providing a flux field acting upon the roller to provide an engaging force between the roller and the resistive element. The roller is mounted using a taut-band, i.e., a twistable metallic band secured to the axis of rotation of the roller which allows a predetermined number of rotations of the roller through twisting of the band. The taut-band resiliently suspends the roller so that it may move perpendicularly with respect to the axis of the rotation of the roller. As a particular advantage provided by this invention, the taut-band suspension, in combination with the magnetic engaging force, provides a unique "kneeing" action when the roller encounters surface imperfections, dirt accumulations or other surface irregularities. More specifically, resilient or elastic movement of the roller away from the resistive element, provided by the taut-band suspension, decreases the engagement force provided by the magnet in accordance with the amount of movement of the roller from the resistive element such that the effort required to move the roller over a surface imperfection decreases as the size of the imperfection increases. It will be appreciated that the engagement force of spring-loaded rollers of the prior art devices increases as the roller moves off the surface of the resistive element against the action of the spring resulting in a requirement of a higher effort to move the roller over a given surface irregularity.

Additionally, the taut-band suspension for the roller according to this invention not only provides an efficient mounting for the roller to provide limited rotation thereof, but also provides a solid non-commutated electrical connection between the roller and the mounting therefore, and in turn, to an accessible terminal output.

For the above reasons, this invention provides a low-torque potentiometer system, i.e., one which only requires approximately 1/400 of the torque input of the prior art potentiometers. Accordingly, the potentiometer of this invention is believed to be a significant advance in the art.

Particularly beneficial results are obtained when the micro-torque potentiometer of this invention is combined with a Bourdon tube so as to provide a pressure transducer providing an electrical output signal. More specifically, a rotating potentiometer according to this invention is connected to a multi-convolution Bourdon tube. The Bourdon tube, for example, may be connected to a source of pressure such as the bulb of a gas absorption thermometer. The extremely low input torque requirement of the potentiometer of this invention provides a pressure transducer which is highly sensitive to very small pressure changes and has exceptionally low hysteresis.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross-sectional view of a pressure transducer utilizing a multi-convolution Bourdon tube in combination with a micro-torque potentiometer according to this invention;

FIG. 2 is a detailed cross-sectional view of a portion of the potentiometer shown in FIG. 1;

FIG. 3 is a sectional view of the potentiometer shown in FIG. 1; and

FIG. 4 is an illustration of another embodiment of a micro-torque potentiometer according to this invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

In FIG. 1, a pressure transducer 10 is illustrated having a micro-torque potentiometer 12 according to this invention. The pressure transducer 10 also includes a Bourdon tube section 14 and a housing 16 containing the potentiometer 12 and Bourdon tube section 14.

The housing 16 comprises a left end closure member 20, a right end closure member 22, a main housing cylindrical portion 24, a ring magnet 26 having an internal cylindrical bore 27, and an annular spacer 28. The right end closure member 22 is secured to the main housing cylindrical portion 24 by a plurality of bolts 30. The left end closure member 20, the spacer 28, and the ring magnet 26 are secured to the main housing cylindrical portion 16 by a plurality of bolts 32 extending therethrough. Suitable gaskets are interposed between each of the housing sections as shown so as to form a fluid tight chamber 34.

The end closure members 20 and 22 are provided with bearing fixtures 36 and 38 respectively, each having an axial pivot indentation (not shown) interior the chamber 34. The bearing fixtures 36 and 38 are mounted on and electrically insulated from the end closure members 20 and 22 by fluid tight gaskets 39. The

axial pivot indentation on bearing fixture 36 accepts the conical end 40 of a shaft member 42 axially positioned within the housing 16. Similarly, the axial pivot indentation of the bearing fixture 38 accepts the conical end 44 of a second shaft member 46 also axially located within the housing 16. The shaft members 42 and 46 are connected in axially spaced relationship at the potentiometer 12 by a flexible resilient coupling 48 constructed of a dielectric material. Accordingly, the shafts 42 and 46 are electrically insulated one from the other. The first shaft 42 is provided with a left end plate 50 affixed thereto for rotation therewith, while the second shaft 46 has a right end plate 52 affixed thereto for rotation therewith. The end plates 50 and 52 may be affixed to the shafts 42 and 46, respectively, by soldering. The left end plate 50 is provided with a pair of taut-band mountings 54 and 56 while the right end plate 52 is provided with a pair of taut-band mountings 58 and 60. A taut-band 62 extends between taut-band mountings 54 and 58 and carries a first contact roller 64 affixed thereto at its axis of rotation, for example, also by soldering. The taut-band mountings 56 and 60 carry a second taut-band 66 having a second contact roller 68 affixed thereto at its axis of rotation, for example, also by soldering. Accordingly, the end plates 50 and 52 are adapted to revolve on shafts 42 and 46, respectively, to cause the rollers to move in a circular path, for example, a path described by a predetermined radius from the center or axis of the potentiometer 12 to the axis of rotation of the rollers 64 and 68.

The construction of the taut-bands and the taut-band mountings can be more clearly seen with reference to FIG. 2 which is an enlarged cross-sectional view of a portion of the second contact roller 68 and the taut-band mountings 60. Referring now to FIG. 2, the contact roller 68 is shown securely affixed to the taut-band 66 by a small bead of solder 70. The taut-band 66 is in turn fixed by means of a solder connection 72 to a taut-band hub 74. The taut-band hub 74 engages a depression 76 in a leaf spring 78 so as to locate the taut-band hub 74 and the taut-band 66 with respect to the leaf spring 78. The leaf spring 78 may be of generally rectangular form (not shown) and constructed of thin spring steel stock. The leaf spring 78 is retained in position with respect to a tower 80 by a leaf spring retainer 82 having a slot therein accepting the leaf spring 78. The tower 80 and the leaf spring retainer 82 are formed of dielectric material, preferably a material such as nylon so that the retainer 82 may be heat-sealed to the tower 80. The tower 80 has outside surfaces consisting of an extreme left portion 84 which radially tapers outwardly to the right, a portion 86 to the right thereof which radially tapers inwardly to the right, a cylindrical portion 88, a radial shoulder 90, and a cylindrical portion 92. The right end plate 52 is provided with a cylindrical opening 94 which has a diameter which is slightly less than the diameter of the crest of the radially tapering portions 84 and 86 of the nylon tower 80 such that the nylon tower 80 may be pressed into position through the cylindrical opening 94. Once the crest of the radially tapered portions 84 and 86 has passed through the opening 94, the resilient material will expand to engage the tapered portion 86 with the right end plate 52. Intermediate the shoulder 90 of the nylon tower 80 and the right end plate 52, a spring washer 96,

a conical retaining washer 98 and a lug washer 100 are interposed. The spring washer 96 is of wavy configuration as can be best seen in FIG. 1 so as to provide a resilient force acting through the retaining washer 98 and lug washer 100 to bias the nylon tower 80 to the right so as to retain the radially tapered portion 86 in engagement with the end plate 52. A resilient force provided by the leaf spring 78 serves to maintain axial tension on the taut-band 66 and thus to locate the axis of rotation of the roller 68.

The right side of the taut-band 62 and the left side of the taut-band 66 are provided with integral extensions 102 and 104, respectively. The extension 102 is electrically connected to the lug washer 106 by a solder connection 108, while the taut-band extension 104 is electrically connected to the lug washer 100 by a solder connection 110. The lug washers 100 and 106 are electrically connected to the respective mounting plates 52 and 50 by conductors 114 and 112, respectively.

The contact rollers 64 and 68 each comprise an annular main portion 116 and a central web or connecting member 118. A central axial bore 120 is provided which accepts the taut-band 62 or 66. The annular portion 116 has a pair of triangular projections 122 at opposite ends thereof which provide a pair of outwardly extending sharp circular ridges at 124. The annular projections 124 and 126 of the rollers 64 and 68, respectively, are aligned with the left and right faces of the magnet 26 to provide maximum flux linkage through the rollers 64 and 68. Accordingly, maximum attractive force between the rollers 64 and 68 and the magnet 26 is provided. As can be seen in the drawings, the rollers 64 and 68 are each symmetrical about its center axis, and additionally, are each rotatable about that axis by their twisting of the taut-band 62 or 66. It should be understood that the rollers 64 and 68 do not rotate with respect to the taut-band portion passing therethrough, i.e., the rollers 64 and 68 are not rotatably journaled with respect to the taut-bands 62 and 66, since they are securely affixed to the taut-bands by a soldered connection.

For reasons which will be apparent later, the rollers 64 and 68 are preferably constructed in a light-weight fashion of magnetic material. By the term magnetic, it is herein meant that the material is highly permeable to magnetic flux, but is not necessarily magnetized so as to be a flux source.

A layer of polyethylene film 126 such as mylar is affixed to the cylindrical bore portion 27 of the magnet 26 such as by an adhesive. A resistive layer or coating 128 is formed on the mylar film 126 for example, by deposition, to provide a conducting surface portion or element insulated from the magnet 26 which has a predetermined resistivity per unit length along the surface. The configuration of the resistive surface 128 and the polyethylene film 126 may be better seen with reference to FIG. 3 in which a cross-sectional view generally along lines 3—3 of FIG. 1 is shown. As can be seen in FIG. 3, the polyethylene film 126 extends around the entire cylindrical bore portion 27 of the magnet 26, while the resistive layer 128 extends only approximately 300° from point *a* to point *b*. Accordingly, an arcuate surface from point *a* to point *b* is provided which is non-conductive and a complementary arcuate resistive surface from *b* to *a* is provided

which is conductive. The arcuate resistive layer 128 may be dimensionally defined by a predetermined radius from the center of the potentiometer 12. A first conductor 130 is also provided connecting termination point *a* of the resistive layer 128 with a positive terminal of a source 132 of electric potential, while a second conductor 134 is provided connecting termination point *b* with the negative terminal of the source 132 of electric potential. It will be appreciated that a potential drop *E* occurs along the resistive layer 128 from termination point *a* to termination point *b*. By virtue of current flow through the layer 128, a potential gradient, or variation of the potential with distance along the resistive layer 128 is provided. The potential gradient may be varied either by adjusting the thickness or the width of the layer 128.

As can be seen in FIG. 3, the annular projections 124 of contact rollers 64 and 68 engage the resistive layer 128 so as to provide electrical conduction therebetween. Since the rollers 64 and 68 are diametrically mounted with respect to the axis of the potentiometer 12, contact with the resistive layer 128 by the respective contact rollers 64 and 68 is spaced apart 180° about the arcuate resistive layer 128. It will now be appreciated that an electrical circuit is completed from the resistive layer 128, through the roller 64, the taut-band 62, the taut-band extension 102, the lug washer 106, the conductor 112, and the left end plate 50, to the shaft 42. Accordingly, the potential on the shaft 42 will be substantially equal to the potential derived from the resistive layer 128 by the contact roller 64. Moreover, the potential derived from the resistive layer 128 will be in accordance with the position of engagement of the contact roller 64 on the resistive layer 128 with respect to the termination points *a* and *b*. Similarly, the roller 68 derives a potential from the resistive layer 128 by contact therewith which is transmitted through the taut-band 66, the taut-band extension 104, the lug washer 100, the conductor 114, and the right end plate 52, to the shaft 46. In a like manner, the potential on the shaft 46 derived from the resistive layer 128 is in accordance with the position of engagement of the contact roller 68 with respect to the termination points *a* and *b* of the resistive layer 128.

To transmit the electric potential on shaft 42 to an accessible terminal 136 electrically connected to the bearing fixture 36 exterior the housing 16, a flat spiral spring member 138 is utilized having a first end 140 electrically connected and non-rotatably affixed to the shaft 42, and a second end 142 electrically connected and non-rotatably affixed to the bearing fixture 36 to provide electrical conduction therebetween. In a like manner, the potential on shaft 46 is transmitted to an external terminal 144 connected to the right bearing pivot 38 by a flat spiral spring member 146 having a first end 147 electrically connected and non-rotatably affixed to the shaft 46, and a second end 148 electrically connected and non-rotatably affixed to the bearing fixture 38 to provide electrical conduction therebetween. The coils of the spring members 138 and 146 are constructed of very light metallic spring material so as to provide little resistance to relative rotary movement between the shafts 42 and 46 and their respective bearing mounts 36 and 38.

The Bourdon tube section 14 includes an elongated multi-convolution helical Bourdon tube 150 which is arranged coaxially within the chamber 34 and is adapted for winding and unwinding motion in response to internal pressure within the convolutions as is well known in the art. As illustrated, the convolutions of the Bourdon tube 150 are generally oval shaped in transverse cross section and define a continuous helical passage 152 that is communicable with an external source of pressure through an input tube 154 connected to the extreme left convolution 156 of the Bourdon tube 150 and extending exteriorly of the housing 16. The extreme right convolution of the Bourdon tube 150 is sealed in a conventional manner to provide a closed passageway.

The left end of the Bourdon tube 150 is restrained from rotary movement within the chamber 34 by virtue of the connection of the left convolution 156 to the input tube 154. One of the convolutions to the right of the convolution 156, for example, convolution 158, is fixed to the central shaft 46 by means of a generally radially extending take-off member or spider 160. The spider 160 includes a central section 162 having an axially extending tubular flange portion 164 that defines a central axially extending bore 166 through which the shaft 46 extends and is fixedly secured. For example, the shaft 46 may be secured to the spider member 160 by soldering or the like. Projecting radially outward from the central section 162 are three equally circumferentially spaced arm sections, two of which are shown as 168 and 170. The arm section 170 and the arm section not shown are each formed with a portion extending to the right disposed directly adjacent the inner surface of the Bourdon tube 150 and are adapted to serve in a stabilizing or centralizing function to maintain the Bourdon tube 150 concentrically oriented with respect to the shaft 46. For example, the arm section 170 has a flange portion 172 extending to the right engaging the inner surface of the convolution 174 of the Bourdon tube 150. The arm section 168 is formed with a generally U-shaped mounting portion 176 which defines a slot or recess 178 facing to the left within which the convolution 158 of the Bourdon tube 150 is received and fixedly secured, for example, by crimping or soldering. With the above construction, it will be seen that winding and unwinding movement of the Bourdon tube 150, in response to variations in the pressure therewithin, will cause rotational movement of the shaft 46 via the spider 160. To prevent shorting of the potential on the shaft 46 to the housing 16, means (not shown) are provided to electrically insulate the shaft 46 from the Bourdon tube 150, for example, by a non-conducting hub bushing for the spider 160, a non-conducting layer interposed between the spider 160 and the Bourdon tube convolution 158, or through utilization of a non-conducting material for the spider 160. The Bourdon tube 150 is particularly suitable for use as a pressure indicator because of its substantially linear response to pressure changes, i.e., each unit of pressure change produces substantially the same rotational movement or deflection of the shaft 46. A particular feature of the above described construction resides in the fact that the Bourdon tube section 14 may be adjusted for pressure span by merely adjusting the relative rotational position of the take-off spider 160 with

respect to the Bourdon tube 150. This may be accomplished merely by unsecuring the U-shaped mounting portion 176 of the spider 160 from the convolution 158 of the Bourdon tube 150, after which the spider 160 as well as the shaft 46 secured thereto is rotated some preselected amount, the mounting portion 176 may again be secured, as by mechanically crimping or soldering or the like, to the convolution 158.

It can now be appreciated that rotation of the Bourdon tube 150 in response to changes in the pressure therein causes rotation of the shaft 46 which rotation is transmitted to the potentiometer portion 12 of the pressure transducer 10 so as to cause rolling contact of the rollers 64 and 68 on the resistive element 128, and consequent transmission of a potential representative of the position of the rollers 64 and 68 on the resistive surface 128 to the external terminals 136 and 144. Thus, variations in pressure delivered to the Bourdon tube 150 result in variations in the electric potential measurable at terminals 136 and 144 in accordance therewith.

The chamber 34 is intended to be supplied with, and contain, a preselected quantity of a relatively viscous fluid material which is adapted to be arranged in generally surrounding relation with at least a portion of the helical Bourdon tube 150, and thereby function to limit or dampen movement of the tube 150 when the assembly 10 is subjected to shock, vibration or other movement which might impart relative movement to the Bourdon tube 150. While such damping fluid may comprise any one of a number of materials well known in the art, said fluid is preferably in the form of a silicon oil having a viscosity of approximately 18,000 centistokes, although this viscosity may be varied in accordance with each operating condition with which the unit 10 may be associated. The quantity of vibration and shock damping fluid with which the chamber 34 may be supplied is selected such that a portion of the Bourdon tube 150 is engaged or submerged within the fluid regardless of the particular orientation of the assembly 10, with the result that the fluid will be effective in achieving its damping function when the assembly 10 is oriented in virtually any position.

Any non-linearity in the winding or unwinding of the Bourdon tube 150, or in a source of pressure connected to the input tube 154, may be compensated for by adjusting the width of thickness of the resistive layer 128 so as to adjust the potential gradient therealong.

The weight of the rollers 64 and 68 is preferably made small compared with the attractive force of the magnet 26 so that the contact pressure between the rollers 64 and 68 and the resistive layer 128 is nearly constant regardless of the orientation of the unit 10. For example, the rollers 64 and 68 may be constructed so as to weigh 1 gram whereas a magnet 26 may be provided which provides an attractive force of 20 grams between the rollers 64 and 68 and the magnet 26. Accordingly, the rollers 64 and 68, when positioned vertically above the axis of the potentiometer 12, would engage the resistive layer 128 with a force equal to the magnetic attractive force of 20 grams, minus the roller's weight of 1 gram, yielding a net engaging force of 19 grams; while the rollers 64 and 68, when positioned vertically below the axis of the potentiometer 12, will engage the resistive layer 128 with a force equal to the

attractive force of 20 grams, plus the roller's weight of 1 gram, yielding a net engaging force of 21 grams. Therefore, between these positional extremes, a variation in engaging pressure between the rollers 64 and 68 and the resistive layer 128 of only 2 grams or 10 percent is experienced.

In FIG. 4, another embodiment of a potentiometer according to the present invention is shown. The pressure transducer 182 of FIG. 4 includes a Bourdon tube 150 and spider member 160 essentially as described with respect to the embodiment 10 of FIG. 1. The transducer 182 includes a ring magnet 184 which has a cylindrical bore portion 186 and a cylindrical outer portion 188. The outer portion 188 is provided with a layer or sheet of polyethylene film 190 such as mylar which has a resistive coating or layer 192 thereon extending approximately 270° about the periphery of the magnet 184 and having terminations *a* and *b* at the extremities thereof, generally as taught with respect to the embodiment of FIG. 1. It should be noted that in this embodiment, however, the resistive layer 192 is formed on the outer periphery of the magnet 184 rather than on the bore portion as shown and taught with respect to FIG. 1.

The pressure transducer 182 also has a roller 194 with a pair of triangular projections 196 engaging and making electrical contact with the resistive layer 190 in alignment with the edges of the magnet 184. The roller 194 is connected to the spider 160 by means of an axial central shaft 198, and a connecting radially aligned shaft 200 having an axially aligned shaft extension 202 at one extreme end journally carrying the roller 194 for rotatable movement thereon. Alternately, a taut-band extension as described with respect to the embodiment of FIG. 1 may be utilized by substituting taut-band carrying left and right end plates for the shafts 200 and extension 202 as will be apparent. The other extreme end of the shaft 200 is provided with an axially oriented shaft extension 204 having a counter-weight 206 secured thereto to balance the rotary movement produced by the weight of the contact wheel 194.

The pressure transducer 182 is provided with a source 208 of electric potential connected to the terminations *a* and *b* of the resistive element 192 by means of conductors 210 and 212 respectively to establish a potential gradient along the resistive element 192.

In view of the above description of the structure of the pressure transducer 182, it will be appreciated that the contact wheel 194 receives a potential from the resistive layer 192 in accordance with its position on the resistive layer 192 with respect to the termination points *a* and *b*. This potential may be derived from the contact wheel 194 by any known commutator or in the manner described with respect to FIG. 1.

The pressure transducer and variable potentiometer of the present invention may be converted into a gas absorption thermometer by connecting a bulb filled with an absorbent material, for example, activated carbon, to the input tube 154 of the Bourdon tube 150. The absorbent material has an ability to absorb very large quantities of certain gases in accordance with the absolute temperature of the bulb containing the absorbent material. As the temperature of the bulb increases, the material is less capable of absorbing gases, and as a result, gases are emitted from the bulb into the

Bourdon tube thereby raising the pressure therein and causing rotation of the shaft 46, and a consequent increase in potential at the output terminals 136 and 144.

The combination of the taut-band suspension, the contact rollers, and the means providing a magnetic attraction force between the contact rollers and the resistive element as taught by this invention provides a potentiometer which requires extremely low torque input for its operation even when surface irregularities on the resistive element are encountered by the contact rollers. More particularly, consider the action of the rollers, the taut-band suspension and the magnetic engagement force between the rollers and the resistive element when surface irregularities such as a surface projection on the resistive element is encountered by the rollers. As a roller engages the projection, it tends to "knee" or cam over the projection, i.e., lift from the normal surface of the resistive element by virtue of the flexibility of the taut-band suspension. As the roller lifts from the normal surface of the resistive element, the force attracting the roller to the resistive element decreases since the flux coupled through the roller decreases. Accordingly, the effort required to move the roller over the projection is reduced thereby aiding the "kneeing" or camming action. As a result of the above described action, surface imperfections and the like provide minimal resistance to movement of rollers along the resistive element.

It will be understood that the multi-convolution Bourdon tube of this invention may be replaced by a bimetallic element, for example, a multi-convolution element which winds and unwinds in response to temperature variation. Moreover, the rotary potentiometer herein described may be converted to a linear potentiometer by replacing the annular magnet with a bar magnet which has a flat resistive element thereon to provide linear translational movement of the roller therealong. In this regard, the linear potentiometer could be operated by a bellows, diaphragm, or accelerometer.

While it will be apparent that the teachings herein are well calculated to teach one skilled in the art the method of making the preferred embodiments of this invention, it will be appreciated that the invention is susceptible to modification, variation and change without departing from the proper scope or meaning of the subjoined claims.

What is claimed is:

1. A potentiometer comprising:

an elongated resistive element adapted to be connected across a source of electrical potential;

a roller engaging and making electrical contact with said resistive element for deriving an electrical potential therefrom; and

means mounting said roller for rolling movement along said resistive element including a metallic band affixed to said roller in electrical continuity therewith at said axis of rotation which is adapted to twist in response to rotation of said roller about said axis, said band providing resilient movement of said roller perpendicularly with respect to said axis of rotation.

2. A potentiometer according to claim 1 wherein said metallic band extends from each side of said roller and said mounting means resiliently applies tension to said

metallic band so as to generally locate said roller axis and to provide said resilient movement of said roller perpendicularly with respect to said axis of rotation.

3. A potentiometer according to claim 1 wherein said resistive element is defined in its elongated direction as the arc of a circle having a center located at a first predetermined radius from said resistive element, and said mounting means mounts said roller at a second predetermined radius for rotation of said roller axis about said center to provide arcuate movement of said roller in engagement with said resistive element.

4. A potentiometer according to claim 3 wherein said first radius defining said elongated direction of said resistive element is less than said second radius defining the movement of said roller axis.

5. A potentiometer according to claim 3 wherein said first radius defining said elongated direction of said resistive element is greater than said second radius defining the movement of said roller axis.

6. A potentiometer according to claim 1 additionally having a second roller engaging and making electrical contact with said resistive element for deriving a second electrical potential therefrom.

7. A potentiometer according to claim 6 wherein said resistive element is defined in its elongated direction as the arc of a circle having a center located at a first predetermined radius from said resistive element, and said mounting means mounts said rollers at a second predetermined radius for rotation of said rollers axes about said center to provide arcuate movement of said rollers in engagement with said resistive element.

8. A potentiometer according to claim 1 wherein said roller includes a portion of magnetic material, and further including means providing a magnetic field acting upon said roller effective to establish a predetermined engaging force between said roller and said resistive element.

9. A transducer comprising:

a multi-convolutional helical Bourdon tube;

rotatable means connected to at least one convolution of said Bourdon tube for rotation therewith;

an elongated resistive element adapted to be connected across a source of electrical potential;

a roller engaging and making electrical contact with said resistive element mounted for rolling motion along said resistive element so as to derive a potential therefrom in accordance with the position of said roller on said resistive element; and

means connecting said roller with said rotatable means for movement of said roller along said resistive element in accordance with the rotation of said rotatable means, and consequently, in accordance with the rotation of said convolution, said connecting means for said roller including a metallic band affixed to said roller in electrical continuity therewith at the axis of rotation of said roller which is adapted to twist in response to rotation of said roller about said axis, said band providing resilient movement of said roller perpendicularly with respect to said axis of rotation.

10. A transducer according to claim 9 wherein said resistive element is defined in its elongated direction as the arc of a circle having a center located at a first predetermined radius from said resistive element, and said mounting means mounts said roller at a second

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predetermined radius for rotation of said roller axis about said center to provide arcuate movement of said roller in engagement with said resistive element.

11. A transducer according to claim 10 wherein said first radius defining said elongated direction of said resistive element is less than said second radius defining the movement of said roller axis.

12. A transducer according to claim 10 wherein said first radius defining said elongated direction of said resistive element is greater than said second radius defining the movement of said roller axis.

13. A transducer according to claim 9 additionally having a second roller engaging and making electrical contact with said resistive element for deriving a second electrical potential therefrom.

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14. A transducer according to claim 9 wherein said roller includes a portion of magnetic material, and further including means providing a magnetic field acting upon said roller effective to establish a predetermined engaging force between said roller and said resistive element.

15. A transducer according to claim 14 wherein said resistive element is defined in its elongated direction as the arc of a circle having a center located at a first predetermined radius from said resistive element, and said mounting means mounts said roller at a second predetermined radius for rotation of said roller axis about said center to provide arcuate movement of said roller in engagement with said resistive element.

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